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DESIGN AND ANALYSIS OF CAR CHASSIS

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ABSTRACT

This work is a step to find out the best optimized design of a car chassis taking material of pipe, pipe diameter and the thickness of pipe as prime parameter. We have accomplished this stress analysis, with the help of ANSYS software and Taguchi methodology. The Stress analysis of the car chassis will fit all aspects and concepts according to the rules of Marathon Challenge. The objective of this project is to design best car chassis. We did this to avoid any possibilities of failure in the structure and also to provide an enough stronger supporting member to make the chassis stronger in terms of deformation. After making the frame, we analyzed it for compressive stress due to the impact loading and identified the region of maximum stress and its possible value. We did the same procedure for nine combinations of material, thickness and diameter according to orthogonal array and observed the induced stress. We predicted that the M_3+T_3+D_3 will give the optimum result of induced stress. We checked the stress for M_3+T_3+D_3 and found it satisfactory. Finally, we derived a mathematical model for inducing stress for impact loading with the help of MATLAB software. Result of induced stress both from ANSYS and mathematical models are same.

KEYWORDS: Chassis Design, ANSYS, Impact Forces, Matlab, Taguchi Method

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Original Article

INTRODUCTION

The chassis is like a skeleton of car body, which give support to the outer body, engine and other elements of the vehicle. Design of chassis depends upon load of the vehicle and the limit of maximum speed of the vehicle. Force considered on the chassis always is equal to the rate of change of momentum of the body during the impact. During the collision of vehicle, maximum stress induced in chassis is crushing stress. We have taken pipes of different material, thickness and diameter to make chassis of small cars (Quad bike)

Objectives

The objectives of the paper are as follows:

- The selection of material for chassis.
- To construct the appropriate chassis
- To determine the maximum stress concentration areas.

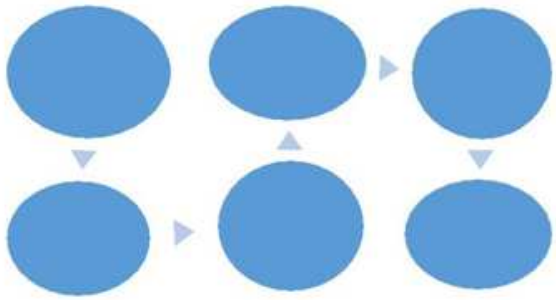

Figure 1.1: A Model of CAD

Table 1

3D CAD	DESIGN		
MODELLING		ELEMENTAL	
		ANALYSIS	
	ANALYTICAL		
MATERIAL	CALCULATIO		
	NS	CONCLUSIO	
SELECTION		N	

Chassis

The chassis is a skeleton frame made up of pipes and other materials of various cross sections.

The chassis must consist of stability, torsional rigidity, as well as it should have a relatively high degree of flexibility, as there is no suspension. It can also be an adequate strength to sustain a load of operator and other accessories. The chassis is designed with convenience and safety for operators. The chassis was designed for a safe ride and the load is applied to it without compromising the structural strength.

METHODOLOGY

This technique is completely based on statistical concepts. Many renowned firms have achieved great success by applying this method. The Taguchi method adopted experimentally to investigate the influence of parameters such as material stress, thickness and diameter of pipe on the induced stress in the chassis. The Taguchi process helps to select or to determine the optimum combination of material stress, thickness of pipes and diameter of pipe and the effect of these parameters on induced compressive stress on the chassis during the time of collision. Many researchers developed many mathematical models to optimize these parameters to get maximum induced stress in various processes.

PHILOSOPHY OF THE TAGUCHI METHOD

- Quality of product depends on the process by which it has been produced. One can improve the quality by optimizing the parameter affects the process.
- Better quality can be achieved by minimizing uncontrollable environmental factor which leads to deviation from a target.
- The cost of quality should be measured as a function of deviation from the standard and the losses should be measured system wide.

PROCEDURE AND STEPS OF TAGUCHI PARAMETERS DESIGN

Step-1: Selection of the Quality Characteristic

There are three types of quality characteristics in the Taguchi methodology, such as **smaller-the-better, larger the- best, and nominal-the-best**. For example, smaller-the-better is considered, when measuring fuel consumption of fuel in automobiles or roughness in surface finish. The goal of this research was to find the effect of parameters and achieve maximum compressive stress induced during collision.

Step–2: Selection of Noise Factors and Control Factors

In this step, the controllable factors are material (M), thickness of pipe (T) and diameter of pipe (D) which was selected because these are the factors which affect the induced compressive stress. Since these factors are controllable so they are considered as controllable factors in the study? Uncontrollable factors may be the ambience temperature, Humidity, road quality and human error.

Step-03: Selection of Orthogonal Array

There are 9 basic types of standard Orthogonal Arrays (OA) in the Taguchi parameter design. Selection of arrays depends on the degree of freedom of a selected parameter. Degree of freedom of all three parameters is 6. An L_9 Orthogonal Array is selected from Appendix B, 2nd edition, 2005, Taguchi Techniques for Quality Engineering, Philip J Ross, Tata McGraw-Hill Publishing Company limited, for this work.

An L_9 Orthogonal Array is selected for this work. The layout of this L_9 OA is, as mentioned in Table 3.1.

Table 3.1: The Layout of L_9 OA Array

Experiment	P1	P2	P3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Step-4: Conducting the Experiments

Table 3.1 illustrates the experimental settings in this study for maximum compressive stress. The parameters used in this experiment are material (three different materials), thickness of pipe (three different thicknesses) and the diameter of pipe (three different diameters). All nine analyses have been conducted on ANSYS software results of which have been observed.

Step-5: Predicting Optimum Performance

Using the aforementioned data, one could predict the optimum combination of material, thickness and diameter for maximum compressive stress induced during impact of collision. With this prediction, one could conclude that which combination will create the best result. A confirmation of the experimental design was necessary in order to verify the optimum variable combination.

Step-6: Establishing the Design by using a Confirmation Experiment

The confirmation experiment helps to verify our prediction, particularly when small fractional factorial experiments are utilized. The purpose of the confirmation experiment in this study was to validate the optimum compressive stress induced during collision.

DESIGN

The chassis is designed, considering the factors like factor of safety - maximum load carrying capacity, force absorption capacity, required space for accessories and driver and specific dimensions.

The design of the chassis is performed by using software's ANSYS. The load distribution in the chassis should be uniform. The structural design gives the idea about the chassis.

MODELING

The 3-D modelling of Chassis is created by ANSYS:

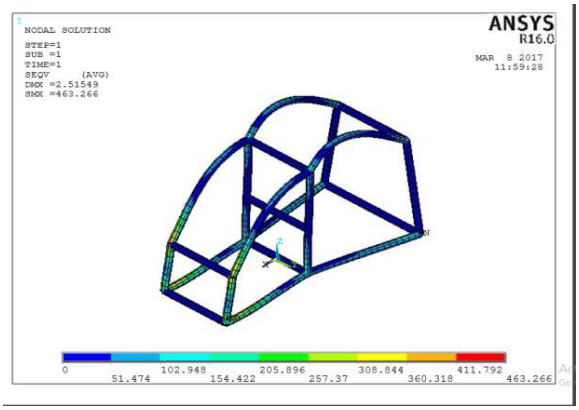

Figure 6.1: Modelling Design of Chassis on ANSYS

Analysis

The next stage after the design is an analysis of the chassis under various impact forces and overall dynamic loads applied during the race. By performing analysis, the stresses induced in the structure can be determined.

Analysis of Means

The analysis of each controllable factor is studied and the main effect of the same is obtained in table 5.4. The main effect of each factor at individual level i.e.at low, medium, high levels is equal to the mean of hardness of all experiments with the factor at the individual level.

The main effect of material on stress at various levels calculated as follows.

M_1 = (463.24+290.10+196.95) /3 = 316.77

M_2 = (363.93+233.11+322.42) /3 = 306.27

M_3 = (294.44+374.14+246.77) /3 =305.11

The main effect of thickness on stress at various levels calculated as follows.

T_1 = (463.24+363.93+294.44) /3 = 373.87

T_2 = (290.10+233.11+294.44) /3 = 272.55

T_3 = (196.95+322.42+246.77) /3 = 255.38

The main effect of depth of cuts on hardness at various levels calculated as follows.

D_1 = (463.24+322.42+374.14) /3 = 386.6

D_2 = (290.10+363.93+246.77) /3 = 300.26

D_3= (196.95+233.11+294.44) /3 = 241.5

Table 6.1: Results Obtained After Analysis

Symbol	Controllable Factors	Hardness (HRC)		
		L	M	H
M	Material	316.77	306.27	**305.11**
T	Thickness	373.87	272.55	**255.38**
	Diameter	386.	300.26	241.5

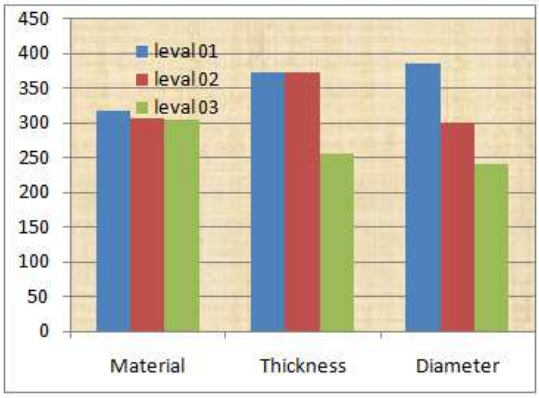

Figure 6.2: The Graphical Representation of the Result Found

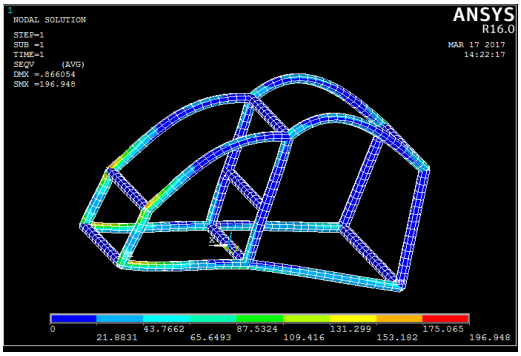

Figure 6.3: Result on ANSYS

Conclusion

The thesis has discussed parameters and indicates that the Taguchi design of experiments is an effective way of determining the optimal combination of parameter.

The outcome of the calculation and formulation of the optimization of Taguchi method, are summarized.

An application of Taguchi method for optimizing the design

Table 6.2: The Outcome of Calculation by Taguchi Method

Results	Induced compressive stress by ANSYS	Induced compressive stress by Mathematical formula
Level	$M_3 + T_3 + D_3$	$M_3 + T_3 + D_3$
Induced stress (MP)	196.948	197

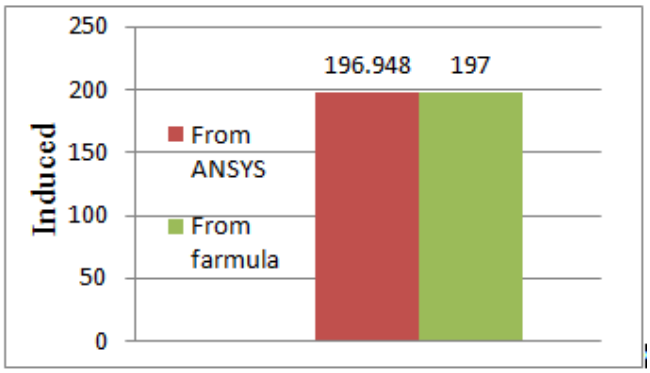

Figure 6.4: Graphical Representation of the Outcome

CONCLUSIONS

From the response graph plotted between parameters, it is observed that there is a decrease in induced stress as the yield stress, Thickness of the pipe and diameter of pipe are increased

From response table and graph, observational findings are illustrated as follows.

- **Level III for Material = lower induced stress** indicated as the optimum situation in terms of the mean value.
- **Level III for Thickness of pipe = lower induced stress** indicated as the optimum situation in terms of the mean value.
- **Level III for Diameter of pipe = lower induced stress** indicated as the optimum situation in terms of the mean value.

The result obtained from the confirmation experiments reveals that the Taguchi method has provided the best prediction for the response value By the application of Mathematical regression modelling researcher has found out the empirical formula, which shows the relation between these three factors i.e. yield stress, thickness, diameter. By the use of this formula, we can find out the value of stress at the time of impact at any given combination between a given range.

Future Scope

However, the research work can be extended as a future scope by taking various other factors and level of combinations. In this way, one can design and analyze the chassis with different aspects to make safe and economic.

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